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Abstract

Managerial intuition is a well-recognized cognitive ability but still poorly understood for the purpose of developing effective decision support systems. This research investigates whether the differences in accuracy of "time series forecasting" are related to the differences in one's cognitive style, using statistical test The hypotheses established in the research model did not have positive correlation The lack of correlation between "cognitive style and physiological measures" and accuracy in forecasting may be caused by uncontrolled external variable. Thus, further analyses on physiological characteristics and brainwaves are needed. The approaches such as neural network and data mining are proposed.

Category: Technical
Keywords: Decision Making, Cognitive Style, EEG, Judgemental Time Series Forecating, Emotion Engineering, Decision Support Systems

Introduction

"Judgmental time series forecasting" is prediction of events based on the past data contained in the time series, as opposed to "rational choice," which is formed from causal relationship. Although statistical method is generally utilized in predicting an event, intuitive judgment is also used. Intuitive judgment is used widely since it can be applied in areas where statistical prediction cannot be used; however it is not without potential errors. The main factors that deter the accuracy of "judgmental time series forecasting" have not yet been closely studied. This study investigates whether the differences in accuracy of "time series forecasting" are related to the differences in one's cognitive style. In other words, the way an identical time series are dealt must vary between an analytical person and an intuitive person. The paper makes note of the fact that these cognitive differences influence the accuracy of one's "time series forecast." As of now, there have not been many studies in the cognitive styles and accuracy in "time series forecasting." On the other hand, inaccuracy and errors that can result from relying on intuition can be found in decision-making related literature (Hogarth & Makridakis, 1981; Tversky and Kahneman, 1974).

A human being's brain is divided into left and right halves with each having different functions. The left half deals with the analytical process while the right counterpart handles more emotional and intuitive functions (Stein et al., 1990). Therefore studying the changes in both left and right side of the brain according to one's cognitive style can lead to an interesting discovery. This research is to investigate the accuracy of "time series forecasting" according to one's cognitive style, using statistical test, and proposed the other approaches such as neural network and data mining for deriving the cognitive/physiological characteristics that influence "judgmental time series forecasting."

Background

Cognitive Style in Decision-Making

Singh (1998) demonstrated that the cognitive supporting aids as well as the decision support systems enhanced the effectiveness and the efficiency of decision making.

Through researches on intuitive judgment and cognitive styles, Kuo (1998) discovered that the top economists rely on their keen intuition to aggressively solve their problems. Knowledge necessary for problem solving is dispersed in one's inmost thoughts and environs, which explains why intuition may be able to more effectively solve dynamic and abstract problems. In addition, most of the businesses rely on intuitive forecasting as their main tools in their business activities as more experiments prove that "judgmental forecasting" is more accurate and efficient compared to statistical forecasting (Lim et al., 1998). Ruble and Cosier (1990) studied on effects of cognitive styles and decision setting on performance based on 162 economic-majoring students. Davis, Grove and Knowles (1990) divided 96 graduate students into categories of four decision-making styles and put them through computer-simulation, which situated them in an economic environment. The result confirmed significant differences in cost effectiveness among different decision-making styles. Furthermore, it was discovered that intuitive decision-making was more likely to be used when there is high uncertainty, no past data or experience is available, many variables are scientifically unpredictable, there is time constraint, or many alternatives exist (Agor, 1986).

Physiological Approaches for Cognitive Task

EEG provides the necessary information on essences of cognitive styles (Wilson and Fisher, 1995). Although identical information may be given, each person processes it differently using different parts of the brain, according to their cognitive styles. In general, analytical person emits less alpha wave in all parts of the brain compared to his holistic counterpart (Riding, Glass, Buttler and Pleydell-Pearce, 1997).

In order to examine the areas of the brain human uses in "judgmental time series forecasting," he controlled the environment to stimulate auditory, visual, and olfactory senses, and prepared scenarios to induce desired emotions. EEG and GSR were measured from laryngitis and frontal lobe to study the effects that emotion played on the brain, and the result confirmed that one was able to forecast more accurately when feeling was negative as opposed to positive feeling.

Research Model and Hypotheses

The following study examines the correlation between cognitive styles and physiological characteristics, and their final outcomes.

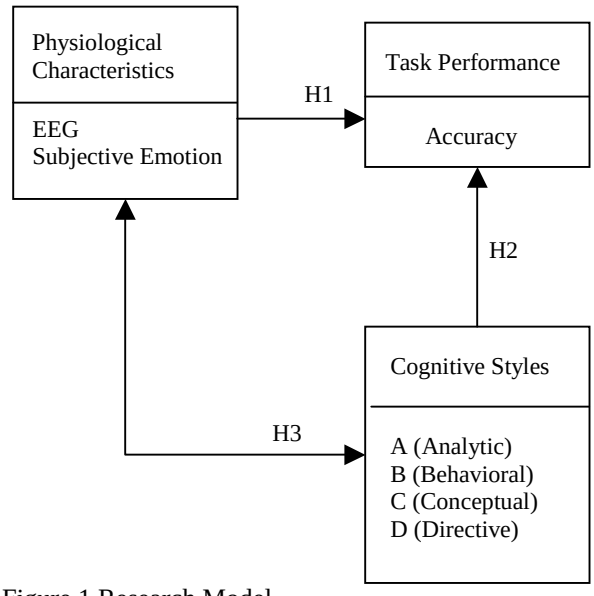

Figure 1 Research Model

The following hypotheses can be constructed using the above model as a basis.

H1: There is no correlation between accuracy in "judgmental time series forecasting" and brain waves.

H2: Accuracy in "time series forecasting" differs among different cognitive styles.

H3: Differences exist in brain waves among different cognitive styles.

In the next section, hypotheses H1 and H2 will be further analyzed to see how the quality of decision is affected by the characteristics of the decision-maker. Hypothesis H3 will be analyzed as the relationship between cognitive style and characteristics of physiological response is further examined.

Research Methodology

Experiment Design

To carefully examine the above model, the following experiment was prepared. IT junior and senior undergraduate students and graduate students were used as test subjects. The subjects have taken decision-making related classes in the past. They were physically fit so as to prevent distortion in physiological signals.

The experiment was on time-series forecasting. Time-series data was derived from M-Competition (Makridakis et al., 1996). More precisely, the time-series data given to the test subjects was number of PCs sold in a month and they were to assume that they were PC sales managers. Total of forty data were given which was the sales volume for each month for the period of three years and four months. They were asked to predict the sales volume for

next eight months. No other data, such as cause-and-effect data were not provided except for the given times-series data. Consequently, the differences of two cognitive styles-- analytical and intuitive-- were to be decided solely on their ability to solve the time-series problem.

Experiment was carried out individually to measure his/her physiological signals. In order to minimize variance in experiment, one person performed the entire test while standardizing the instruction given for all subjects. To classify subjects' decision style, we used Alan Rowe's Decision Style Inventory derived form the work of noted psychiatrist Carl Jung. Physiological characteristics were analyzed by EEG, while of the many brain waves, alpha and beta waves were examined since they are closely linked to problem solving. Quality of decision-making is defined as accuracy in decision making and accuracy in forecasting the given test. Process of experiment is as follows:

(1) Read the instruction when the subject enters the room.
(2) The researcher gives a brief summary of the experiment.
(3) Prior to the experiment, measure subject's subjective emotion. Measuring subjective emotion in advance is to prevent distortion in controlled environment that may arise due to differences in subjects' emotion prior to the experiment.
(4) Collect the subjective emotion survey and attach transference to the body for measuring brain waves.
(5) Make the subject close his eyes and meditate in a comfortable position with clear mind (2 min.).
(6) Measure the brain wave while having the subject in resting position (1 min.).
(7) Have the subject open his/her eyes and proceed with test (app. 1 min.).
(8) End the test. Measure his/her subjective emotion by giving the survey. Measure subject's cognitive style, which is the only independent variable of the research.

Measures and Observation

(1) Independent Variable

In this research, we adopted the decision style classification scheme, which is the basis for many measures of decision style including the popular Myers-Briggs Type Indicator test (Myers, 1962). And we used Alan Rowe's Decision Style Inventory to measure the subjects' decision styles such as A (analytic), B (behavioral), C (conceptual), and D (Directive) (Rowe and Boulgarides, 1994).

(2) Dependent Variable

The following experiment measures accuracy, physiological measures, and subjective emotion.

Accuracy: Accuracy of time-series forecasting is measured by MAPE. MAPE is a universally used tool in time-series forecasting and represented in absolute percentage value of standard deviation of forecasted value from actual value.

Physiological measures: This experiment measures the EEG to discover physiological responses related to decision-making. Alpha and Beta, the main brainwaves, are analyzed.

Subjective Emotion: A subject's emotion is measure using five-point Lickert scale.

Results and Discussions

T test and ANOVA were used for the results of this experiment. For statistical package, SPSS for Windows (v. 9.0) was used.

Results of analysis is as follows:

(1) Correlation between accuracy in time-series forecasting and brainwaves was not found.
(2) No differences exist in accuracy of time-series forecasting between different cognitive styles. The differences within the cognitive style were comparatively large; therefore, the difference between the groups was hard to see.
(3) According to the cognitive style, brain waves of left and right halves of the brain have the tendency to concentrate in one side of the brain.

The lack of correlation between "cognitive style and physiological measures" and accuracy in forecasting may be caused by uncontrolled external variable. Further analysis on characteristics of physiological response and brainwaves are needed.

Artificial Intelligence based Approaches

The hypotheses established in the research model did not have positive correlation. However further research is possible if artificial neural network and data-mining technologies can be utilized. Following method is suggested where an artificial neural network is used to determine the degree of correlation among many parameters. In this analysis, Self-organizing neural network , which is representative of SONN.

Secondly, data mining technology can be used. This research analyzes in various ways by using cognitive style data and characteristics of physiological response to discover which positively influence intuitive forecasting. Using data mining technology, previously established hypotheses are confirmed as well as to automatically explore other existing rules. By doing so, database can be

created by categorizing research data and find systematic relationship from it. Discovered rules are then verified using statistical hypotheses verification method or neural network technology.

Conclusion

Most of the psychologists and decision scientists agree that intuition capacity must be supported for important decision making process. However, hardly any previous research has been made where decision makers' intuition capacity is examined. Furthermore, research that includes cognitive physiological elements is even more rare. The significance of this research is to discover cognitive/physiological element that can improve outcome of intuitive forecasting. It is the basic research which can foster the environment for quality decision making, which will further enhance decision support system. In other words, the research assures the first basic technology that combines strong intuition of decision maker with computer analytical capability for establishing research tool of next-generation decision support system.

Subject of next research is as follows: influence of decision maker's cognitive style on the quality of unstructured decision-making; intuition capability of decision maker and physiological/cognitive characteristic research; and cognitive tool for supporting intuition capability of decision maker. Additional research will be carried to bring light to these issues.

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